THE CALIBRATION OF SURVEY EQUIPMENT

(An ancient concept in a modern setting.)

PRESENTED AT THE

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SURVEY EQUIPMENT CALIBRATION

INTRODUCTION

The calibration of survey equipment is not a new issue. The concept goes back to the earliest of times when surveyors checked or calibrated their measuring devices against the standard of the day. Many active land surveyors will remember the use of the ‘standard tape’ to ‘calibrate’ their steel tapes. In fact there was a time when obtaining a standard tape was part of the requirements of obtaining one’s commission.

The advent of electronic distance measuring equipment required the establishment and use of baselines to calibrate this type of equipment. Later on when global positioning systems became the measuring tools of the day validation base nets were added to the list of calibration tools.

This brings us to today, the second century of our particular organization, along with all the great proliferation of total stations, GNSS and other instruments used in conjunction with the modern measuring tools. Therefore the need for calibration policies and procedures to specifically document a concept that has been part of all surveyors’ training for as long as surveyors have been around.

SURVEY EQUIPMENT CALIBRATION

ABSTRACT

The main theme of this paper is the ‘why’, ‘what’ and ‘how’ of a formal calibration policy.

The definitions of calibration and validation are reviewed. The main reasons for a formal calibration policy are discussed which leads into a discussion of what such a policy might look like.

This paper used the term calibration, which in many cases could be exchanged with the term ‘adjustment’.

The paper then discusses the various parts of a mock policy. This discussion is followed by a review of how such a policy might be implemented.

The various pieces of equipment are reviewed as the methods of calibration along with the documentation of the proceedings. The focus is on total stations, prisms, tribrachs and prism / antenna poles.

The paper concludes by reviewing some examples of how to complete a calibration.

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CALIBRATION OR VALIDATION WHAT DO WE MEAN?

The terms calibration and validation require some explanation.

First we need to define calibration in the context of survey equipment.

> ***Calibration*** *is a comparison between measurements – one of known magnitude or correctness made or set with one device and another measurement made in as similar a way as possible with a second device.*
>
> *The device with the known or assigned correctness is called the standard. The second device is the unit under test, test instrument, or any of several other names for the device being calibrated.*

From the EDM Calibration Manual we have:

> *These guidelines describe the four Electronic Distance Measurement (EDM) calibration baselines in the province of Alberta as well as how to undertake an EDM calibration baseline survey. They have been developed to assist users in verifying that their EDM equipment is working within the EDM manufacturer's stated specification for scale error and constant error. The guidelines also include requirements for submission of EDM calibration survey data to the Geodetic Control Unit, Surveys and Technical Services Section for evaluation.*

Further to the process of simply testing against a known value it is often possible and therefore necessary to make adjustments to the equipment to bring it back into calibration. For the purposes of this discussion the terms calibration and adjustment may both be used to describe the process of bringing a piece of equipment into specifications.

The validation process differs significantly from calibration. Validation goes beyond simple calibration. The validation process includes the following:

- The equipment;
  - Is it capable of achieving the required accuracy under project conditions;
  - Are the resulting measurements within specifications, that is, is it properly calibrated?
- The procedures used in the field as well as in the office;
- In some cases even the personnel become part of the process.

From the Edmonton GPS Validation manual we have:

> *The validation networks may also be used to evaluate proposals from GPS survey contractors. A "validation survey" on a GPS basenet may be required to assess the proposed GPS positioning system, and determine with confidence whether it can meet contract accuracy requirements. A positioning system in this context includes the equipment and procedures used for data collection as well as the software and procedures used for the data processing and adjustment.*

SURVEY EQUIPMENT CALIBRATION

Why do we need a formal written calibration policy?

Why do we need a written policy on equipment calibration? Is this not something that we do in our day to day operations without actually documenting the procedure as calibration?

Gone are the days when most everything was done without a lot of paperwork. Nowadays everything has to be documented. This requirement affects us in all walks of life. *If it is not written down it never happened.*

First and foremost from the Surveys Act we have:

> ***Standard of measure***
>
> *11(1) The measure of length used in surveys made under this Act must be the Canadian or the International System measure of length defined by the Weights and Measures Act (Canada).*
>
> *(2) A surveyor shall verify*
>
> *(a) all tapes used by the surveyor by comparison with a subsidiary standard of a type approved for that purpose by the Director or by a person authorized in writing by the Director, and*
>
> *(b) all electronic linear measuring devices used by the surveyor by comparison with calibration base lines established by the Minister for that purpose.*

The practice review board is of the opinion that in order to remain competent within the context of the modern geomatics environment it is necessary to develop and implement such a policy as well as the regular checking and calibration of all surveying equipment and auxiliary equipment such as thermometers and barometers.

Then we have other considerations:

> Many of our clients, large long term construction site projects in particular, require documentation of a calibration policy.
>
> If there is ever a question as to measurements, in particular when there is some disagreement, the mere fact that there is a policy in place may well quell any further questions regarding equipment. If you can also show that you are adhering to this policy there should not be any further doubts.
>
> It just makes sense to have a policy that staff can refer to when the question of calibration comes up.

SURVEY EQUIPMENT CALIBRATION

WHEN TO DO AN EDM CALIBRATION?

When to calibrate will come up later, however since when may be as important as why we can look at it now as well as later.

From the “EDM Calibration BL Manual” we have;

In general, there are three situations under which a Land Surveyor or other users of EDM equipment conduct EDM calibration surveys.

1. *As a requirement for an Alberta Survey Control project for the establishment and/or maintenance of Alberta Survey Control Markers (ASCMs).*
2. *Statutory requirement under Part 1, Section 11(2),(b) of the Surveys Act which requires an Alberta Land Surveyor to verify all electronic linear measuring devices used by him by comparison with calibration base lines established by the Minister for that purpose.*
3. *Check the quality of the EDM in situations where it has been damaged during regular surveying operations or when the EDM is old and may no longer be operating within the manufacturer’s specifications.*

Policy versus procedure:

At this point let us look at the terms policy and procedure in this setting.

Policy:

Policy is plan of action adopted by an individual or organization. The term is similar to the term legislation or an Act.

Procedure:

Procedure is a prescribed set of instructions or steps to be taken to achieve the goals of a policy. The term is similar to regulations pursuant to a piece of legislation.

If policy can be described as the what, procedure would be the how to.

What should a calibration policy include?

A calibration policy should outline objectives of the organization in the context of calibration of surveying equipment. The following is a sample outline of such a policy.

Policy Statement:

This organization wishes ensure that all surveying equipment and auxiliary measuring equipment are maintained in such so that all measurements made, using owned or rented equipment, are accurate and reliable. To that end we are committed to the equipment calibration policy and the implementation of the policy and its procedures.

SURVEY EQUIPMENT CALIBRATION

Scope:

The requirements set out in this policy shall apply to all tools and equipment used to make measurements whether these measurements are distances, lengths, angles, temperature or pressure. Furthermore this policy shall apply to all measuring equipment used on any project irrespective of the ownership of that equipment.

Equipment that does not perform to specifications or is prone to go out of adjustment shall be taken out of service. This must then be brought to the attention of the employer.

Responsibilities:

In order for this policy to function certain responsibilities are assigned to both the employer and the employees.

The employer is responsible:

- For the education of the employees with respect to this policy;
- To ensure that selected employees are properly trained to perform equipment calibrations and are capable of assessing the results;
- To ensure that the employees have the means to implement this policy;
- To provide all the necessary forms etc.;
- To ensure that the policy is observed;
- To determine how and when equipment is to be calibrated;
- To determine whether the calibration is done in house, by the vendor or a professional equipment repair and calibration shop;
- Maintain a record of all calibrations performed;

Project managers are responsible:

- To ensure all measuring equipment used on a particular project falls within the scope of this policy;
- To ensure that staff are aware of the policy;
- To ensure that staff have been properly trained to detect when equipment might be out of calibration and how to deal with the problem;

The employees are responsible;

- The actual implementation of the policy;
- Ensuring that equipment is functioning properly;

- That whenever a piece of equipment has been subjected to an incident that would dictate that a new calibration be completed, that such a calibration is performed;
- The recording of the results;
- To inform the project manager of any defective equipment and ensure that that piece of equipment is labeled as “OUT of CALIBRATION”, and is taken out of service until such time as it is performing properly;
- To consult with the employer or project manager as to how to proceed when in doubt;

Procedures:

Whenever a piece of equipment is to be calibrated the following steps must be in place;

- The person(s) performing the calibration must be well acquainted with the specific procedure for that particular piece of equipment;
- The equipment owner’s manual (if any) has been reviewed with respect to the procedure;
- If there is a company procedure in place, that this procedure is reviewed and fully understood;
- All the proper forms must be in hand;

When to calibrate:

There are many reasons why a piece of equipment should be calibrated. Some of those reasons are;

- Statutory as per the Surveys Act or other relevant legislation;
- Event driven, such as:
    - Damaged equipment;
    - New equipment
    - Rental equipment;
- Time driven such as:
    - Heavily used;
    - Un used for an extensive period of time;
    - Prescribed calibration schedules;

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Record keeping:

The simple fact that a piece of equipment was calibrated is in itself a good start, however unless this fact is recorded and filed in the proper format the process becomes exercise in futility. All calibration work shall be recorded in the prescribed manner.

Reporting:

If any piece of measuring equipment is found to be 'out of calibration', this must be reported to the project manager at once. If the faulty equipment can be successfully calibrated or adjusted in the field so that is no longer out of calibration, the procedure may be performed. The 'incident' must still be reported in order that appropriate steps can be taken to ensure that the particular piece of equipment in question can be inspected and cleared for further use.

At this point we have covered the 'why' and the 'what'. We can now move on to the 'how'.

How do we implement a calibration policy?

There are several steps to be taken to move from simply having a policy to the actual implementation of the goals set out in the policy.

Education:

The first responsibility of the employer is the education of all employees that use measuring equipment, manage projects, or work with the observations made with the measuring equipment. The level of detail will vary from group to group however at the very least all employees must be aware of the calibration policy and have a sound understanding of its goals. Without this understanding the goals of the policy cannot be met.

Similar to other polices that affect employees, upper management must lead the charge. One approach that seems to work is to ensure that all those affected by the policy take ownership of the policy, or 'buy into it'.

Training:

A certain path to failure is to simply develop and present a policy and expect it to be accepted whole heartedly without proper education and training. The extent of the training portion of implementation will depend on the number of people involved. In larger organizations it is vital to train more than one person to perform any one function.

The process of performing calibrations and testing will involve project managers as well as field staff. It may not be necessary that each crew chief is fully trained in the process, but it is

necessary that all project manages and crew chiefs are fully conversant with the policy and how it is to be implemented.

Each office should have at least one person who is fully trained to manage the policy and actually perform equipment calibrations.

This includes:

- Determining whether or not a piece of equipment requires testing or calibration;
- Performing the actual calibration / testing process;
- Recording the results;
- Filing, or directing the filing, of the results;
- Maintaining an overall calibration log.

A certain number of field personnel must also be trained to complete the required field observations for all types of calibration and testing as well as to perform basic calibrations in full.

WHEN to CALIBRATE:

The timing of the calibration or testing of equipment is dependent on a number of factors and can therefore not be prescribed in a rigid manner. This procedure outlines events that will lead to some form of testing to ensure correct readings are obtained as well as provide timing guidelines.

Events that could lead to testing:

Events that could lead to testing include:

- Equipment is damaged;
- Equipment has been subjected to shock;
- Equipment has been repaired;
- Rental equipment;
- New equipment;
- A significant change in weather or elevation since its last test or use;
- The recommended time limit for a specific piece of equipment has expired;
- A change in the combination of total station/EDM and reflectors;

SURVEY EQUIPMENT CALIBRATION

Recommended timing of calibration, assuming none of the above events would dictate an additional test.

- Steel tapes, annually and prior to an official survey;
- EDM and total stations annually or when required for an official survey.
- Reflectors, annually;
- Barometers annually or when move to a significantly different elevation;
- Thermometers, annually;
- Tribacs quarterly, bubble and centering device;
- Reflector/antenna poles and bubbles, at least weekly, bubble, verticality and straightness;
- Levels, before each project and as often as required during a project to ensure its proper adjustment;
- Leveling rods and rod bubbles at the start a project and in conjunction with the level;

METHODS of CALIBRATION:

Each piece of survey equipment has its own unique requirements and must be tested in a manner designed to determine whether or not that particular piece of equipment is providing the correct results.

This procedure does not go into detail as to the actual performance of any test or calibration. It simply outlines the general method or procedure to be used. The owners' manuals are a good source of information to assist in testing, adjusting or calibration.

Whenever one piece of equipment is tested against another it is paramount that the second piece has been calibrated, tested and or adjusted and therefore is the standard.

The following table outlines the basic methods and conditions for performing calibrations, testing or adjustments.

Methods Table:

EQUIPMENT	TESTED AGAINST	CONDITIONS	COMMENTS
Steel tapes	Approved standard tape	Both tapes to be at the same temperature and fully supported	Use tension handles
Cloth tapes	Any tested steel tape	Correct steel tape for	Use tension handles

		temperature.	
Level rods	Any tested steel tape	Correct steel tape for temperature if rod face is metal	
Rod Bubbles	Known vertical		Ensure testing item is in fact vertical.
Thermometer	A thermometer known to be correct	Allow enough time for the thermometers to acclimatize.	
Barometers	A barometer known to be correct		If done at an airport ensure that it is the ABSOLUTE pressure you are given.
Pin Locators	Test at a known iron post before use	Known post should be counter sunk or keep pin locator at least 60cm away	Ensure that the batteries have enough charge.
Levels	Two peg test and adjust	Test as required, could be daily.	On larger projects setup a 'baseline'
EDM / TS distances	Approved baseline OR Project baseline	Overcast days are best	Ensure that all the required information is recorded.
Prisms	Part of baseline test	Easiest be done on unknown baseline	
Prism poles	Test for vertical with a total station	Test bubble in office testing bracket.	Adjust bubble as required
Tribrachs	Test and adjust in office test bracket	Ensure that all screws are tight	
Total stations	Check horizontal angles and 'adjust' as per the user manual.		Always double critical angles
	Check vertical angles and		Always double vertical

	'adjust' as per the user manual.		angle on turning stations
Pipe Locators	Test at known location	The test location MUST be verified with locator of a different type	

DOCUMENTATION:

Every bit as important as the actually testing, adjustment and calibration, the documentation of the process is the only method of proving that the work was completed.

Documentation Table:

In all cases the date and the person(s) completing the task must be recorded.

EQUIPMENT	SERIAL No.	TEMPERATURE PRESSURE	HOW DOCUMENTED	Calibration label
Steel tapes	If possible	T	In field notes, copy in calibration folder	Y
Cloth tapes	If possible	T	In field notes, copy in calibration folder	Y
Level Rods	If Possible	T	In field notes, copy in calibration folder	Y
Thermometers	If possible	T	In field notes, copy in calibration folder	Y
Barometers	Yes	T & P	In field notes, copy in calibration folder	Y
Pin Locators	Yes	T	In field notes, copy in calibration folder	Y
Levels	Yes	T	In field notes, copy in calibration	Y

			folder	
EDM & TS distances	Yes	T & P	Preferably on proper forms Job folder and calibration folder.	Y
Prisms	MMM No.	T & P	Notes or on the EDM forms Job folder and calibration folder.	Y
Prim poles	If possible MMM No	n/a	In field notes, copy in calibration folder	Y
Tribrachs	If Possible MMM No	n/a	In field notes, copy in calibration folder	Y
Total Stations H & V Angles	Yes	T	In Calibration folder	Y
Pipe Locator	Yes	T & P	Field notes and calibration folder	Y

n/a denotes note applicable T denotes temperature P denotes pressure

The ‘Calibration Label’ column suggests that a ‘calibration label’ be applied to each piece of equipment. In the case of equipment such rods, prism poles and tribrachs etc. that may be tested relatively often it would not be practical to maintain the label with dates etc. as there simply would not be sufficient space to keep that sort of information on the label. It would make more sense to keep a simple log which is available to anyone using the equipment.

. Depending on the size and material of specific calibration labels this may not be practical.

The importance of recording any adjustments or calibrations cannot be over emphasized.

APPENDICES

Appendix A

Calibration examples;

Appendix B

Baseline forms;

Appendix C

Daily check forms;

Appendix D

Edmonton Baseline EXCEL Spread sheet;

Appendix E

Tribrach checking and adjustment;

Appendix F

Prism / Antenna pole checking and adjustment;

Appendix G

Web sites and information sources;

APPENDIX A

THREE CALIBRATION EXAMPLES

EXAMPLES

LEVEL CALIBRATION

- **TWO PEG TEST**

EDM CALIBRATION

- **UNKNOWN BASELINE**
- **KNOWN BASELINE**

SURVEY EQUIPMENT CALIBRATION

LEVELING ERRORS:

What errors are we able to detect, eliminate or minimize.

Bubble out of adjustment

An out of adjustment bubble causes backsight readings to be either too high or too low while the foresight readings will be the opposite**.**

Effect CANNOT be minimized by field methodology.

Cross hairs out of adjustment

- all readings to be either too high or too low;
- can be minimized;

Other Sources:

- the rod and turning points;
- applies equally to normal and digital levels;
- remedies are somewhat different;

DETECTING AND ELIMINATING LEVELING ERRORS

CONVENTIONAL & DIGITAL automatic levels

If it is suspected that the main automatic levelling system is out of adjustment the instrument should be adjusted by a professional repair shop.

By field procedure;

The normal and best method of minimizing errors in leveling due to instrument misadjustment is to follow the time tested practice of keeping backs sights as close to equal as practical. This procedure should be followed for each individual set up as well as the total back sights and fore sites between bench marks. This procedure is much simplified with the advent of digital levels that also read the distance to the rod.

CHECK CIRCULAR BUBBLE:

The adjustment of the circular bubble is a two-step process.

First centre the bubble in the circle;

- turn the level 180°;
- bring the bubble one half of the way back to the centre of the circle using the bubble adjustment screws;
- bring the bubble to the centre of the circle;
- repeat these steps until the bubble stays well within the circle at all times;

MISS ALIGNMENT of the CROSS HAIRS

The detection of the miss alignment of the crosshairs is accomplished and corrected by the two peg test. The two peg test works on the theory that if the distance from the level to the rods is the same, then the error due to any cross hair miss alignment will be equal and therefore eliminated.

SURVEY EQUIPMENT CALIBRATION

THE TWO PEG TEST:

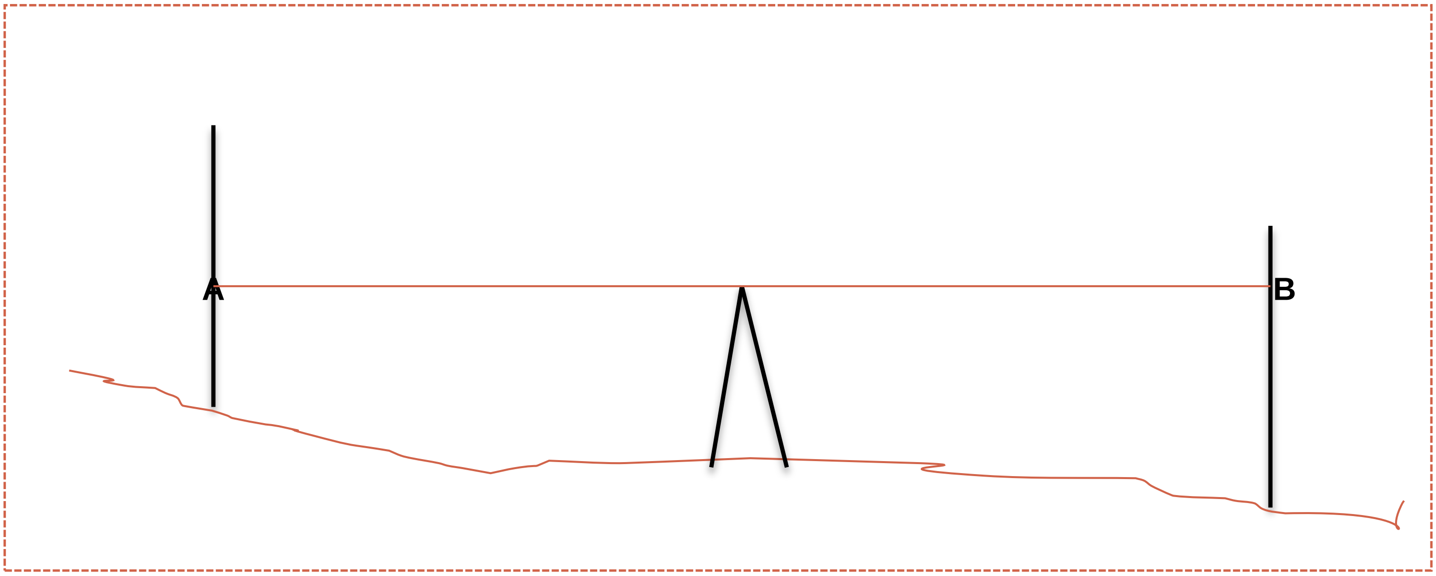
The two peg tests works on the principal that the line of sight through the level is in theory a level plane. It is in fact, a very shallow cone with the apex at the instrument. When the distances from the instrument to the rod are equal, the errors are canceled out, therefore giving the true difference in elevation between A and B.

In order to complete a two peg test the following is required;

- The level to be tested;
- A good rod;
- A tape (20 m or longer);
- A good tripod;
- Two iron bars or something else suitable for setting two temporary bench marks or turning points;

Set the two turning points approximately 40 metres apart. The ground should be level and solid. There must be a suitable setup point in the middle and approximately 2m past one end of the line between the points. Set a lath or other suitable marker at the midpoint between the turning points using the tape. You must be able to read the rod clearly from 2 m past the end of the line to the far rod, or move the instrument further away until you can clearly read the rod. Adjust the baseline to suit your particular level.

STEP 1: Level in the middle.

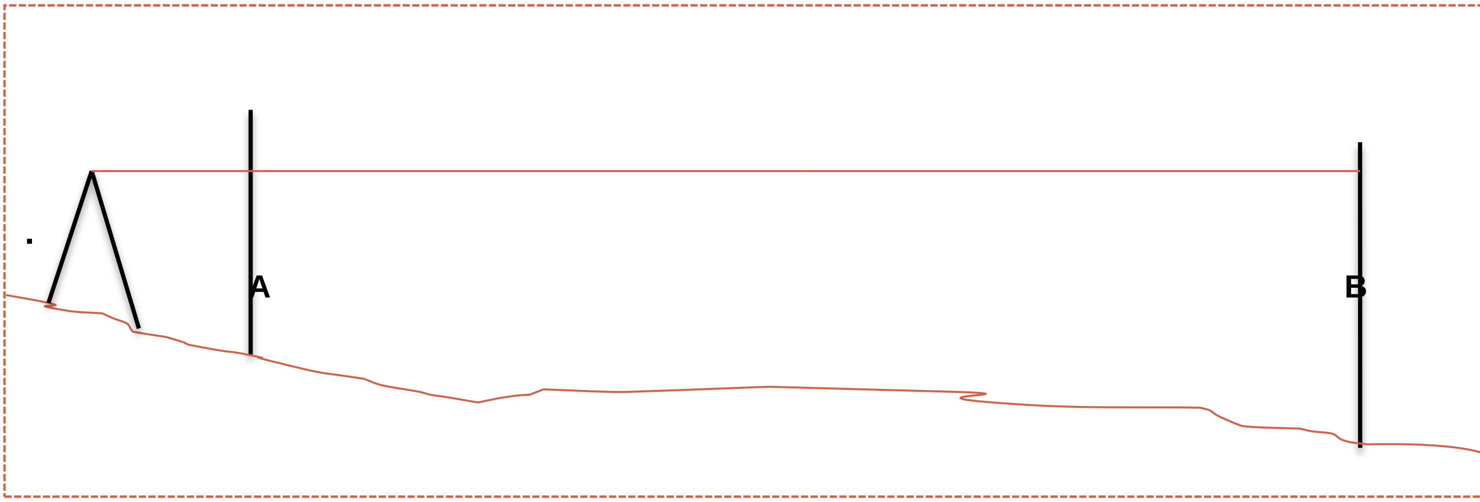


Read and record both the ‘A’ rod and the ‘B’ rod. The difference between the readings is the true difference in elevation between ‘A’ and ‘B’.

FIRST SETUP: Instrument in the middle

BS A	FS B	DIFF (A-B)		
1.752	2.103	-0.351		

Set up level at the end .



SECOND SETUP: INSTRUMENT SET UP PAST THE END

FS A1	FS B1	DIFF (A1-B1)	CORR. FS B1
1.752	2.103	-0.351	
1.575	1.929	-0.354 (0.003)	1.926

Now adjust the cross hairs to read the correct reading of 1.962 at ‘B’. Re read the road at ‘A’, there should not be a significant difference from the initial reading at ‘A’.

Assuming 40 m between rods we have 0.003/40 =0.0001m per metre or a maximum of 0.0002 difference in the reading at rod ‘A’. If there is a significant difference in reading then the second setup should be repeated in full.

SECOND SETUP: FINAL READINGS

FS A1	FS B1	DIFF (A1-B1)	CORR. FS B1
1.575	1.926	-0.351	1.926

UNKNOWN BASELINE CHECK:

Another method of checking the total station prism combination is the so called unknown base line check. It is a simple procedure that requires 3 tripods and tribrachs and one prism.

Set the three tripods up in a line, lined up by eye is good, at a spacing of 30 to 50 metres, they do not need to be setup over anything. The tripods or tribrachs are **NOT TO BE MOVED** during the procedure.

Tripod A ____________________Tripod B__________________ Tripod C
30-40m 30-40m

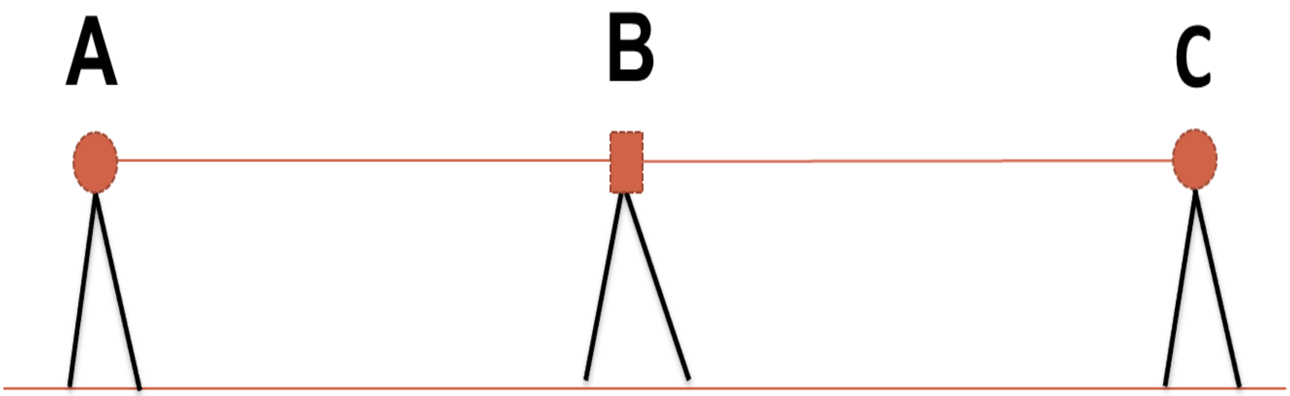
1: Place the instrument in the tribrach at B. Measure B to A and B to C (horizontal distance.)

2: Place instrument in the tribrach at A. Measure horizontal distance A to C

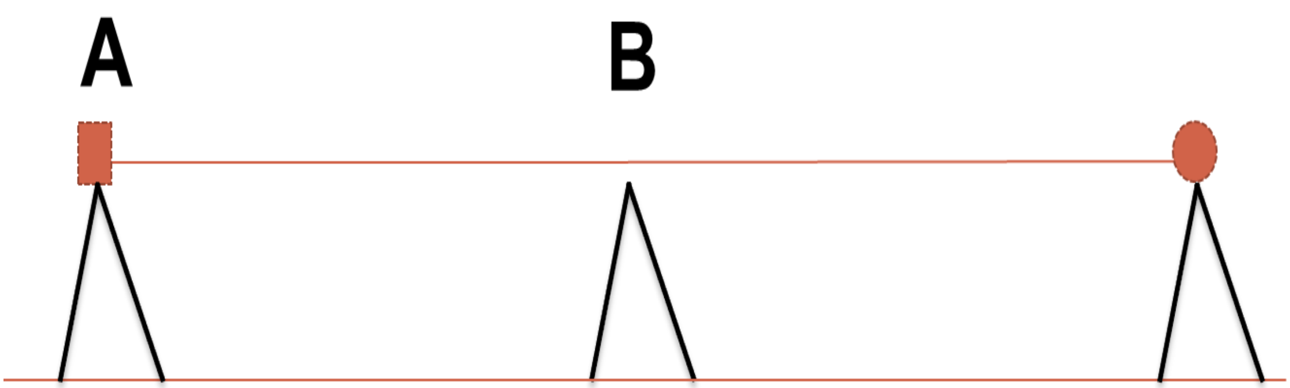
Any error is contained in each measurement. B to A, B to C and A to C, therefore the sum of (B to A) + (B to C) contains the error twice, while (A to C) contains the error only once.

USE ONLY ONE PRISM PER CHECK. DO NOT MOVE TRIPODS or TRIBRACHS.

SET UP 1: Instrument at 'B'. Move the prism from 'A' to 'C'.



SET UP 1: Instrument at 'A'



Instrument at 'B':

- Measure 'B' to 'A'
- **Move the prism to 'C'**
- measure 'B' to 'C'.

Instrument at 'A":

- measure 'A' to 'C'

The table should look like this.

	Measured	Corrected	*Sample*	*Corrected*
B to A	**35.003**	**34.998**	*35.003*	*34.998*
B to C	**42.003**	**41.998**	*42.003*	*41.998*
TOTAL A to C	**77.006**	**76.996**	*77.006*	*76.996*
A to C	**77.001**	**76.996**	*77.001*	*76.996*
ERROR	**0.005**	**0.000**	***0.005***	***0.000***

THEREFORE: the error equals (B to A) + (B to C) – (A to C)

The most important thing to remember is that we are testing the EDM / PRISM combination. We are not testing the ability to setup, tribrachs or anything other than the above.

THE KNOWN BASELINE TEST:

(Edmonton)

The known baseline test is designed to determine both 'scale' and 'prism offsets' in one field operation.

EDMONTON BASELINE

- there are five usable pillars on this baseline;
- there are a total of ten independent measurements that can be made;

They Are:

937+56.14 to

- 937+56.15
- 937+56.16
- 937+56.17
- 937+56.18

937+56.15 to

- 937+56.16
- 937+56.17
- 937+56.18

937+56.16 to

- 937+56.17
- 937+56.18

937+56.15 to

- 937+56.18

You will need:

- the EDM to be tested;
- all the prisms that are to be tested;
- a calibrated thermometer;
- a calibrated barometer;

Note that only one prism(s) can be used to do this test. You must measure all the distances with the same prism.

If more prisms are to be checked this can be accomplished by simply placing each prism in the tribrach at the shortest distance and measuring to it. Remember that it is the prism EDM combination that is being tested.

For the best results prisms should be matched to a particular total station unless all prisms in use are of the same make and model and configured in the same way.

Measure and record all distances.

At each setup measure the

- temperature;
- pressure;
- the instrument height;
- the reflector height;

If you measure the

- SLOPE DISTANCES you will need HI & HT measurements.
- HORIZONTAL DISTANCES you will not need the HI and HT;

Record all observations on the proper form(s).

If you are using the EXCEL spread sheet to do the reductions (see appendix ‘B’ for the sample completed observation and reduction forms) you will need to create the spread sheet.

APPENDIX B

BASE LINE FORMS

- **BAROMETER INFORMATION**
- **THERMOMETER INFORMATION**
- **EDM INFORMATION**
- **OBSERVATION FORM FOR EDMONTON**
- **EXCEL REDUCTION FORM**

SURVEY EQUIPMENT CALIBRATION

FROM ASRD BASELINE MANUAL

Barometer and Thermometer Calibration Form

Date ___________________
Location of Known Standard (Weather Station) _________________________
Observer ___________________

BAROMETER CALIBRATION
User Barometer Make ___________________
User Barometer Model ___________________
Serial # (if applicable) ___________________
Weather Station Barometer Reading (include units) ___________________
User Barometer Pressure Reading (include units) ___________________
Pressure Reading Difference (include units) ___________________

THERMOMETER CALIBRATION
User Thermometer Make ___________________
User Thermometer Model ___________________
Serial # (if applicable) ___________________
Weather Station Thermometer Reading (include units) ___________________
User Thermometer Reading (include units) ___________________

Thermometer Reading Difference (include units) ___________________

EDM Information Form

Agency or Surveying Company ____
Contact Name ___________________
Contact Number (ph)__________________ (fax) ___________________
EDM Make ___________________
EDM Model ___________________
EDM Serial Number ___________________
Measurement Units – Metres □ or Feet □
EDM Prism – Make ___________________ Number of Prisms in Set ___________________

SURVEY EQUIPMENT CALIBRATION

CLIENT: SRD **FILE No.** 2738.09.08

CREW: LD & DM **DATE:** Jan 16 2009

INSTRUMENT: TC 405 **SERIAL No.** 254126

Measure and Record the distances 3 times. For slope distances record the HI and HR for each setup.

WEATHER: *Clear:* [ ] *Cloudy:* [X] *Windy:* [ ] *Snowing:* [ ] *Raining:* [ ] **Check all that apply**.

Inst. at 937+56.14	**Temp (°C)**	**+6**	**Press (mb)**	**932.5**	**HI:**	**0.240**	**HR:**	**0.410**
937+56.15	**937+56.16**		**937+56.17**		**937+56.18**			
120.208	**453.963**		**874.899**		**1437.946**			
120.208	**453.963**		**874.899**		**1437.646**			
120.209	**453.963**		**874.899**		**1437.645**			
120.208	**453.963**		**874.899**		**1437.646**			

Inst. at 937+56.15	**Temp (°C)**	**7**	**Press (mb)**	**936**	**HI:**	**0.240**	**HR:**	**0.410**
	937+56.16		**937+56.17**		**937+56.18**			
	333.759		**754.701**		**1337.475**			
	333.758		**754.701**		**1337.474**			
	333.759		**754.701**		**1337.474**			
	333.759		**754.701**		**1337.474**			

Inst. at 937+56.16	**Temp (°C)**		**Press (mb)**		**HI:**		**HR:**	
			937+56.17		**937+56.18**			
			420.936		**1003.750**			
			420.936		**1003.749**			
			420.935		**1003.709**			
			420.936		**1003.749**			

Inst. at 937+56.17	**Temp (°C)**		**Press (mb)**		**HI:**		**HR:**	
					937+56.18			
					582.865			
					582.866			
					582.865			
					582.865			

NOTE: To convert mm to mb: mm * 1.33333 = mb (741.68 mm * 1.333333 = 988.9 mb)
To convert inches to mb: in * 33.866666 = mb (29.2" * 33.86666 = 988.9 mb)

EDM : LEICA 405 407 25412+6

DATE : Jan 16 09

PRISM 2

SPEC'S

Part A 3 mm

Part B 2 ppm

BASE LINE CALIBRATION RESULTS

	Published DATA					Observations					Computed Values						
LINE	Hor. Dist	Elev A	Elev B	T	P	PPM	HI	HR	Slp Dist	Hor Dist	Cor Dist	Hor Dist	P - O	Ratio	Obs-PC	Diff 2	Ratio 2
14-15	120.195	691.570	689.778	6	933	16.6	0.238	0.135	0.000	120.208	120.210	120.210	**-0.015**	**7757**	120.2060	-0.012	10443
14-16	453.965	691.570	689.302	6	933	16.6	0.238	0.137	0.000	453.963	453.971	453.971	**-0.006**	75253	453.9665	-0.002	221702
14-17	874.913	691.570	690.793	6	933	16.6	0.238	0.000	0.000	874.899	874.914	874.914	**-0.001**	1070825	874.9095	0.003	276185
14-18	1457.594	691.570	706.103	6	933	16.6	0.238	0.133	0.000	1457.646	1457.670	1457.670	**-0.076**	**19057**	1457.6662	-0.073	20104
15-16	333.770	689.778	689.302	7	936	16.5	0.237	0.135	0.000	333.759	333.765	333.765	**0.005**	62072	333.7605	0.009	35651
15-17	754.718	689.778	690.793	7	936	16.5	0.237	0.136	0.000	754.701	754.713	754.713	**0.004**	175040	754.7095	0.008	90967
15-18	1337.399	689.778	706.103	7	736	73.2	0.237	0.133	0.000	1337.474	1337.572	1337.572	**-0.173**	**7725**	1337.5680	-0.169	7906
16-17	420.948	689.302	690.793	6	933	16.6	0.237	0.133	0.000	420.936	420.943	420.943	**0.005**	83930	420.9390	0.009	46770
16-18	1003.628	689.302	706.103	6	933	16.6	0.237	0.130	0.000	1003.749	1003.766	1003.766	**-0.137**	**7312**	1003.7617	-0.133	7531
17-18	582.680	690.793	706.103	6	933	16.6	0.237	0.130	0.000	582.665	582.675	582.675	**0.005**	111370	582.6707	0.009	63219
												Sum	-0.3893				
												Means	**-0.0389**	**162034**		**-0.0349**	**78048**

PRISIM CORRECTION (14-15 + 15-16 - 14-16) **0.0040**

APPENDIX C

DAILY CHECK FORMS

- **RTK CHECK**
- **EDM CHECK**
- **TWO PEG TEST**

SURVEY EQUIPMENT CALIBRATION

DAILY RTK BASELINE CHECK

FILE: _________________ DATE:________________ PC: ________

GPS SYSTEM: _____________TOTAL STATION:______________

Coord. System: __3TM __ UTM __10TM __ LOCAL___________

DATUM: ___ NAD'83(Original) ____ NAD'83(CSRS): ___NAD'27

ORIGIN of COORDIANTES:________________________________

PRE SURVEY CHECK:
Check point: ___________

	Published Coordinates	Observed Coordinates	Delta
N			
E			
H			

POST SURVEY CHECK:
Check point: ___________

	Published Coordinates	Observed Coordinates	Delta
N			
E			
H			

TOTAL STATION CHECK:

Temp: _____C° Pressure: _____mb PPM: _____PPM SET_____

Combined Scale Factor used: ________________

FROM:	TO:	PUBLISHED:	MEASURED:	Delta

SURVEY EQUIPMENT CALIBRATION

TWO PEG TEST (LEVEL)

File: ______________________ DATE:______________ PC: __________

The two peg tests works on the principal that the line of sight through the level is in theory a level plane. It is in fact, a very shallow cone with the apex at the instrument. When the distances from the instrument to the rod are equal, the errors are canceled out, therefore giving the true difference in elevation between A and B.

First setup (Rod at A and B, GOOD turning points):

Rod A_______________________**LEVEL**_____________________ Rod B
20 metres 20 metres

With instrument set up past the end, all of the error is at ROD B1. The new difference between A & B contains the error. The error is the difference between the two differences. To adjust the level, it is forced to read the correct reading at B1 on the second setup by adjusting the line of sight.

Second Setup (Point A1 is point A and point B1 is point B):

LEVEL Rod A1 _______________________________________Rod B1
2 metres 40 metres

INSTRUMENT SET UP IN THE MIDDLE

BS A	FS B	DIFF (A-B)		

THE CORRECT FS TO B1 = FS A1 – (A-B)

INSTRUMENT SET UP PAST THE END

FS A1	FS B1	DIFF (A1-B1)	CORR. FS B1

There is no substitute for maintaining equal BSs, and FSs when leveling.

APPENDIX D

- **EXCEL SPREAD SHEET**
- **EDMONTON BASELINE**

EDM : LEICA 405 25412+6 **407**

DATE : Jan 16 09

PRISM 2

SPEC'S

Part A	**3**	mm
Part B	**2**	ppm

BASE LINE CALIBRATION RESULTS

	Published DATA					Observations					Computed Values							
LINE	**Hor. Dist**	**Elev A**	**Elev B**	**T**	**P**	**PPM**	**HI**	**HR**	**Slp Dist**	**Hor Dist**	**Cor Dist**	**Hor Dist**	**P - O**	**Ratio**	**Obs-PC**	**Diff 2**	**Ratio 2**
14-15	120.195	691.570	689.778	6	933	16.6	0.238	0.135	0.000	120.208	120.210	120.210	**-0.015**	**7757**	120.2060	-0.012	10443
14-16	453.965	691.570	689.302	6	933	16.6	0.238	0.137	0.000	453.963	453.971	453.971	**-0.006**	75253	453.9665	-0.002	221702
14-17	874.913	691.570	690.793	6	933	16.6	0.238	0.000	0.000	874.899	874.914	874.914	**-0.001**	1070825	874.9095	0.003	276185
14-18	1457.594	691.570	706.103	6	933	16.6	0.238	0.133	0.000	1457.646	1457.670	1457.670	**-0.076**	**19057**	1457.6662	-0.073	20104
15-16	333.770	689.778	689.302	7	936	16.5	0.237	0.135	0.000	333.759	333.765	333.765	**0.005**	62072	333.7605	0.009	35651
15-17	754.718	689.778	690.793	7	936	16.5	0.237	0.136	0.000	754.701	754.713	754.713	**0.004**	175040	754.7095	0.008	90967
15-18	1337.399	689.778	706.103	7	736	73.2	0.237	0.133	0.000	1337.474	1337.572	1337.572	**-0.173**	**7725**	1337.5680	-0.169	7906
16-17	420.948	689.302	690.793	6	933	16.6	0.237	0.133	0.000	420.936	420.943	420.943	**0.005**	83930	420.9390	0.009	46770
16-18	1003.628	689.302	706.103	6	933	16.6	0.237	0.130	0.000	1003.749	1003.766	1003.766	**-0.137**	**7312**	1003.7617	-0.133	7531
17-18	582.680	690.793	706.103	6	933	16.6	0.237	0.130	0.000	582.665	582.675	582.675	**0.005**	111370	582.6707	0.009	63219
												Sum	-0.3893				
												Means	**-0.0389**	**162034**		**- 0.0349**	**78048**

PRISIM CORRECTION (14-15 + 15-16 - 14-16) **0.0040**

CONSTRUCTION THE BASELINE REDUCTION SPREAD SHEET

The following is a cell by cell construction of the spread sheet shown above.

Row 1: blank

Row 2:

A2:	**EDM:**	label only
C2:	input EDM brand	Information only
D2:	input EDM model	Information only
I2:	**DATE:**	label only
K2:	input date	Information only
N2:	**SPEC'S:**	label only

ROW 3:

C3: EDM serial number information only
N3: Part A label only
O3: part 'a' of the specification in mm information only
P3: mm label only

ROW 4:

J4: **PRISM** prism number Label only
K4: input prism number information only
O4: part 'b' of the specification in ppm information only
P4: ppm label only

ROW 5: blank

ROW 6:

A6: **BASE LINE CALIBRATION RESULTS** label only
B7: **Published DATA** label only
G7: **Observations** label only
L7: **Computed Values** label only

ROW 8:

A8:	LINE	label only	From - to
B8:	Hor. Dist	label only	Published Horizontal distance
C8:	Elev A	label only	Published elevation from point
D8:	Elev B	label only	Published elevation to point
E8:	T	label only	Temperature in degrees C
F8:	P	label only	Pressure in mb
G8:	PPM	label only	Computed parts per million
H8:	HI	label only	Height of instrument above the plate
I8	HR	label only	Height of reflector above the plate
J8:	Slp Dist	label only	Slope distance if that is what was measured
K8:	Hor Dist	label only	Horizontal distance if that is what was measured
L8:	Cor Dist	label only	the measured distance corrected for met readings
M8:	Hor Dist	label only	the corrected distance reduced to the horizontal
N8:	P-O	label only	the Published Distance MINUS the corrected

SURVEY EQUIPMENT CALIBRATION

OBSERVERED Distance
O8: RATIO label only The published distance divided by the difference
P8: OBS-PC label only the corrected horizontal distance minus PRISM CORRECTION
Q8: Diff 2 label only the PUBLISHED distance MINUS the adjusted distance from column (P)
R8: RATIO 2 label only The published distance divided by the second difference

ROWS 9 to 18:

ONE TIME INPUT ONLY

A9: One time Input From – to last part of station numbers 937+56.14 = 14 etc.
B9: One time Input Published Horizontal distance
C9: One time Input Published elevation from point
D9: One time Input Published elevation to point

FOR EACH OBSERVATION

E9: Input Temperature in degrees C
F9: Input Pressure in mb
G9: FORMULA for specific EDM **=281.8 - (0.29065*F9)/(1 + 0.00366*E9)**
H9: Input Height of instrument above the plate in metres
I9 Input Height of reflector above the plate in metres
(INPUT ONLY ONE OF THE NEXT TWO COLUMNS the other column MUST be EMPTY)
J9: If Measured Input Slope distance if that is what was measured
K9: If Measured Input Horizontal distance if that is what was measured
COMPUTED VALUES:
L9: FOMRULA: **=IF(J9 >0,(1 +G9/1000000) * J9,(1 + G9/1000000)*K9)**
M9: FOMRULA: **=IF(J9 > 0,SQRT((L9 *L9) -((C9 + H9)-(D9+I9))*((C9 + H9)-(D9+I9))),L9)**
N9: FOMRULA: **=B9-M9**
O9: FOMRULA: **=ABS(B9/N9)**
P9: FOMRULA: **=M9 - N22**
Q9: FOMRULA: **=B9-P9**
R9: FOMRULA: **=ABS(B9/Q9)**

Enter the formulae into row 9 and `pull` them down to row 18

ROW 19:

M19: **SUM:** label only The sum of all the differences

ROW 20:

M20: **MEAN:** label only The averages
N20: FORMULA **=average(N9:N18)** average difference
O20: FORMULA **=average(O9:O18)** average ratio
Q20: FORMULA **=average(Q9:Q18)** average difference
R20: FORMULA **=average(R9:R18)** average ratio

ROW 21: blank

ROW 22:

M20: **MEANS:** label only The average of all the differences

H22: **PRISM CORRECTION(14-15 + 15-16 – 14-16)** label only OBSERVATIONS USED

M22: FORMULA **=((M9+M13-M10))** PRISM CORRECTION BASED ON THESE OBSERVATIONS

It is possible to compute more prism corrections, however it is important that distances are not reused.

APPENDIX E

CHECKING AND ADJUSTING

TRIBRACHS

CHECKING AND ADJUSTING TRIBRACHS

CHECKING TRIBRACHS:

The errors generated by a tribrach that is out of adjustment will depend on several factors:

- If only the bubble is out of adjustment;
- If only the plummet is out of adjustment;
- If both are out of adjustment;

These errors are basically unpredictable and impossible to correct for. The one thing that is known is that the total station/prism is not setup over the point, thereby creating an error in distances as well as angles. The only solution is the make sure that the tribrach is checked and properly adjusted.

Checking tribrachs is a very important undertaking. The process consists of two main steps:

- Checking and adjusting the circular bubble;
- Checking and adjusting the optical plummet;

Checking and adjusting the circular bubble:

The purpose of the process is to ensure that when the circular bubble is centered in the circle the tribrach is in fact level.

In order to check the circular bubble one needs a method of ensuring that the tribrach is in fact level. One can use a number of methods to achieve this, among them are;

- Use a target equipped with a good tubular bubble complete with marking;
- The electronic collimation in a modern total station;
- Any other means that utilizes a bubble that is superior to the circular bubble.

Once the tribrach is known to be level, the circular bubble is adjusted by forcing the bubble to the centre of the circle by adjusting the screws that exist for that purpose. Ensure that the bubble is still firmly controlled by these screws.

Checking and adjusting the optical plummet:

The purpose of this process is to ensure that when the tribrach is in fact level the optical plummet is aimed exactly at a point that is known to be precisely under the centre of the tribrach.

The tribrach should be forced centre mounted on a bracket firmly fixed to a wall. A target on the floor must be set by a suitable method that will ensure that the target is precisely under the centre of the tribrach.

With the tribrach level and centred over the target the optical plummet cross hairs are forced to point at the target by using the adjustment screws in the tribrach.

You will now have a tribrach that will, when leveled, in fact be directly over the point within the manufacture’s specifications. This is usually in the order of 1mm per metre above the ground.

APPENDIX F

CHECKING AND ADJUSTING

PRISM / ANTENNA POLES

CHECKING AND ADJUSTING PRISM / ANTENNA POLES

CHECKING PRISM/ANTENNA POLES;

Prism / antenna poles can have the following issues;

- The pole is not straight;
- The circular bubble is out of adjustment;
- The pole is not the correct length;

The first two issues will generate random and unpredictable errors, while the third will generate a constant error that, if detected soon enough, could be compensated for.

Checking and correcting pole straightness;

The straightness of the pole can be checked in several ways;

- Check with a total station, the pole should be straight from top to bottom as the pole is rotated;
- Rolled on a flat surface, the entire pole must stay in contact with the surface;
- Could be checked with a plumb bob;

A bent telescoping pole is not easily straightened, this task is best left to a shop that does this kind of work. If it is badly bent it should be replaced. The normal antenna poles are easier to deal with. However, once bent the pole is more prone to bending after it has been straightened.

Checking and adjusting the circular bubble;

Once it has been determined that the pole is straight the circular bubble can be checked and adjusted if necessary.

The pole has to be vertical, this can be accomplished by using a bracket and a floor point that will ensure that the pole is vertical, or any other means that will ensure that the pole is vertical and held in place to allow the adjusting of the circular bubble. The bubble is adjusted by forcing the bubble to the center of the circle with the adjustment screws. Make sure that the screws are all still snug and that the bubble housing does not move under light pressure.

Check the pole for length;

Antenna poles in particular need to be checked for length. The pole ‘length’ is the distance from the tip to the Manufacture’s Reference Point (MFP) on the antenna. You will need to consult the user manual for the particular antenna to determine where the MFP is. Antenna poles are not automatically interchangeable, even within a single manufacturer.

The length of a prism pole is the distance from the tip to the centre of the prism or the target, depending on the type of prism. Many prism poles have a graduated scale, do not assume that the scale reading will give you the correct prism height. As with antenna poles, prism poles are not automatically interchangeable with the many prism types available. Measure the length.

APPENDIX G

WEB SITES

- **EDM Calibration Manual**
- **Calgary GPS Validation manual**
- **Edmonton GPS Validation manual**
- **EMAIL for 2012 Calibration Presentation**

WEB SITES

This EDM Calibration manual can be found at:

http://www.srd.alberta.ca/LandsForests/DirectorOfSurveys/documents/EDM_Calibration_BL_Manual.pdf

URL for Calgary GPS Validation manual

http://www.srd.alberta.ca/LandsForests/DirectorOfSurveys/documents/CalgaryGPSValidationNetworkManual-Mar-1997.pdf

URL for Edmonton GPS Validation manual

http://www.srd.alberta.ca/LandsForests/DirectorOfSurveys/documents/EdmontonGPSValidationNetworkManual-Mar-1997.pdf

EMAIL for this paper, the 2012 ALSA AGM Calibration presentation

englerh@mmm.ca subject line AGM Presentation